Faculty of Engineering

CONVERSION AND CHARACTERIZATIONS OF BIODIESEL BY TRANSESTERIFICATION OF OLIVE OIL

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Bachelor of Engineering with Honours
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Project Supervisor

Date 6/6/2013

CONVERSION AND CHARACTERIZATIONS OF BIODIESEL BY TRANSESTERIFICATION OF OLIVE OIL

WONG LEH FENG

Thesis is submitted to
Faculty of Engineering, University Malaysia Sarawak
In Partial Fulfilment of the Requirements
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Dedicated to my beloved family and friends, who always bestow me sustainable motivations and encouragements

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ABSTRACT

The consumption of petroleum is increasing ceaselessly in the world. The awareness on depletion and detrimental environmental concerns of fossil fuels has been stimulating the growth of renewable liquid fuel. Vegetable oil has been emerging as the potential substitute of diesel, but it has to be modified into biodiesel to produce its combustion properties closer to those of diesel. In this study, base-catalyzed transesterification was used to derive the biodiesel from olive oil with the presence of methanol and potassium hydroxide (KOH) catalyst under microwave heating. The optimal reaction time was 6 min with total yield of 88%, while the further increase of reaction time led to the reduction of end product. The thermal stability, density, and flash point of the biodiesel were also analyzed. Biodiesel at 9 min reaction time had the highest thermal stability, while biodiesel at 4 min showed the poorest thermal stability. As compared to diesel, biodiesel had greater thermal stability. Thus, biodiesel mixing to diesel made the fuel more stable against heat, as well as to lower the density of the biodiesel in order to meet the ASTM D1298. B20 and B50 had met the ASTM D1298, but their thermogram showed that they are not mixed homogeneously. In contrast, B80 showed the better mixing. Lastly, the flash point of pure biodiesel and biodiesel blends (> 220°C) are higher than diesel (81°C).

Keywords: Biodiesel; Base-catalyzed transesterification; Olive oil; Reaction time; Thermal Stability, Density; Flash point

ABSTRAK

Penggunaan petroleum di dunia telah meningkat secara berterusan. Kesedaran terhadap kekurangan dan pencemaran alam sekitar masalah daripada bahan api fosil telah merangsang perkembangan sumber bahan api cecair yang boleh diperbaharui. Minyak sayur telah muncul sebagai pengganti diesel yang berpotensi., tetapi ia perlu diubah suai menjadi biodiesel supaya ciri-ciri pembakarannya lebih menyerupai diesel. Dalam kajian ini, alkali-pemangkin transesterifikasi telah digunakan untuk memperolehi biodiesel daripada minyak zaitun dengan kehadiran metanol dan pemagkin kalium hidroksida (KOH) di bawah mikro pemanasan. Masa tindak balas optimum adalah 6 min dengan jumlah hasil sebanyak 88%, manakala peningkatan lagi masa tindak balas membawa kepada pengurangan produk akhir. Kestabilan haba, ketumpatan dan titik flash biodiesel juga telah dianalisis. Biodiesel pada 9 min masa tindak balas mempunyai kestabilan haba yang tertinggi, manakala biodiesel pada 4 min menunjukkan kestabilan haba yang paling teruk. Berbanding dengan diesel, biodiesel mempunyai kestabilan haba yang lebih bagus. Oleh itu, campuran biodiesel kepada diesel menjadikan bahan api lebih stabil terhadap haba, serta untuk merendahkan ketumpatan biodiesel bagi memenuhi ASTM D1298. B20 dan B50 telah memenuhi ASTM D1298, tetapi termogram mereka menunjukkan bahawa mereka tidak bercampur homogeneously. Sebaliknya, B80 menunjukkan percampuran yang lebih baik. Akhirnya, titik flash biodiesel tulen dan campuran biodiesel (> 220°C) adalah lebih tinggi daripada diesel (81°C).

Keywords: Biodiesel; Alkali-pemangkin transesterification, Minyak zaitun; Masa tindak balas; Kestabilan haba; Ketumpatan; Titik flash

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LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
Al_2O_3	Aluminium oxide
Al_2O_3/KI	Aluminium oxide/Potassium iodide
B_4, B_5, B_6, B_7, B_8, B_9	Biodiesel at 4, 5, 6, 7, 8, 9 min reaction times
B00, B20, B50, B80, B100	Biodiesel at 0%, 20%, 50%, 80%, 100% blending ratios
BaO	Barium oxide
C14:0	Myristic acid
C16:0	Palmitic acid
C18:0	Stearic acid
C18:1	Oleic acid
C18:2	Linoleic acid
C18:3	Linolenic acid
$CaMnO_3$	Calcium manganese oxide
CaO	Calcium oxide
CaO–CeO_2	Calcium oxide-cerium oxide
$CaTiO_3$	Calcium titanate
$CaZrO_3$	Calcium zirconate
$Ca_2Fe_2O_5$	Srebrodolskite
CEN	European committee for standardization
CH_3O^-	Methoxy radical

CO	Carbon monoxide
CO_2	Carbon dioxide
DG	Diglyceride
DTA	Differential Thermal Analysis
EN	European
Eq.	Equation
ETS-10 zeolite	Ethylene on titanosilicaate-10 zeolite
GHG	Greenhouse gase
HC	Hydrocarbon
K^+	Potassium ion
KNO_3	Potassium nitrate
KOH	Potassium hydroxide
KOH/Al_2O_3	Potassium hydroxide/Aluminium oxide
K_2CO_3	Potassium carbonate
max	Maximum
MG	Monoglyceride
MgO	Magnesium oxide
MSW	Municipal solid waste
Na^+	Sodium ion
NaOH	Sodium hydroxide
$NaOCH_3$	Sodium methoxide
Na_2SO_4	Sodium sulphate
R	Hydrocarbon group
$RCOOR_1$	Ester
ROH	Alcohol

SrO	Strontium oxide
TG	Triglyceride
TGA	Thermogravimetric analysis
TGB	Third generation biofuels
T90 AET	Temperature 90% recovered; Atmospheric equivalent temperature
FAME	Fatty acid methyl ester
FFA	Free fatty acid
FGB	First generation biofuel
SGB	Second generation biofuels
ZnO/I_2	Zinc oxide/Iodine

LIST OF NOMENCLATURE

%	Percentage
°C	Degree celsius
°C/min	Degree celsius per minute
°F	Fahrenheit
b/d	Barrels per day
Btu/gal	British thermal unit/Gallon
cSt	Centistokes
g	Gram
g/cm^3	Grams per centimeter cubed
g/mol	Grams per mole
h	Hours
kg	Kilogram
kg/L	Kilogram per liter
kg/m^3	Kilogram per meter cubed
kPa	Kilopascal
lb/gal	Pound per gallon
L	Liter
mg/kg	Miligram per kilogram
min	Minute
mL	Milliliter
$mL\ min^{-1}$	Milliliter per minute

mm^2/s	Square millimeter per second
M	Molar
MPa	Megapascal
MJ/kg	Megajoules per kilogram
rpm	Revolutions per minute
s	Second
V_{avg}	Average volume
V_T	Total volume
vol.%	Volume percentage
wt.%	Weight percentage
W	Watt

CHAPTER 1

INTRODUCTION

1.1 Overview

The world primary energy consumption grew by 2.5% in 2011 where oil remains the world's leading fuel at 33.1% of global energy consumption (BP, 2012). The world oil production had reported to increase by 1.3% in 2011, meanwhile the world oil consumption increased by 0.7% as compared with 2010. In 2012, worldwide oil consumption increased by 1.3 million barrels per day (b/d) and forecasted to increase by 1.5 million b/d in 2013 (Radler, 2012). At the end of 2011, world proved oil reserves reached 1652.6 billion barrels which is sufficient to meet 54.2 years of global production. Asia Pacific founded about 41.3 thousand million barrels of oil reserves, in which 5.9 million barrels was constituted by Malaysia (BP, 2012).

Figure 1.1 shows the oil production and consumption in Malaysia from the year of 2001 to 2011. There was a peak production in Malaysia during 2004 which is about 762 thousand b/d and followed by drastic decrease in the succeeding years. In 2011, the oil production had a drop of about 10.9%. However, the oil consumption increased continuously with the growth of 0.7%. This is due to the energy use is the most essential requirement for human existence. It is indeed the livewire of industrial, food and agricultural manufacture, the fuel for transportation as well as for the electricity generation in conventional thermal power plants. The world would hit a limit on the amount of oil could be extracted from the ground. According to Kuhlman (2007), oil is now being consumed at a rate of four times faster than it is being discovered, and thus the circumstances is becoming critical.

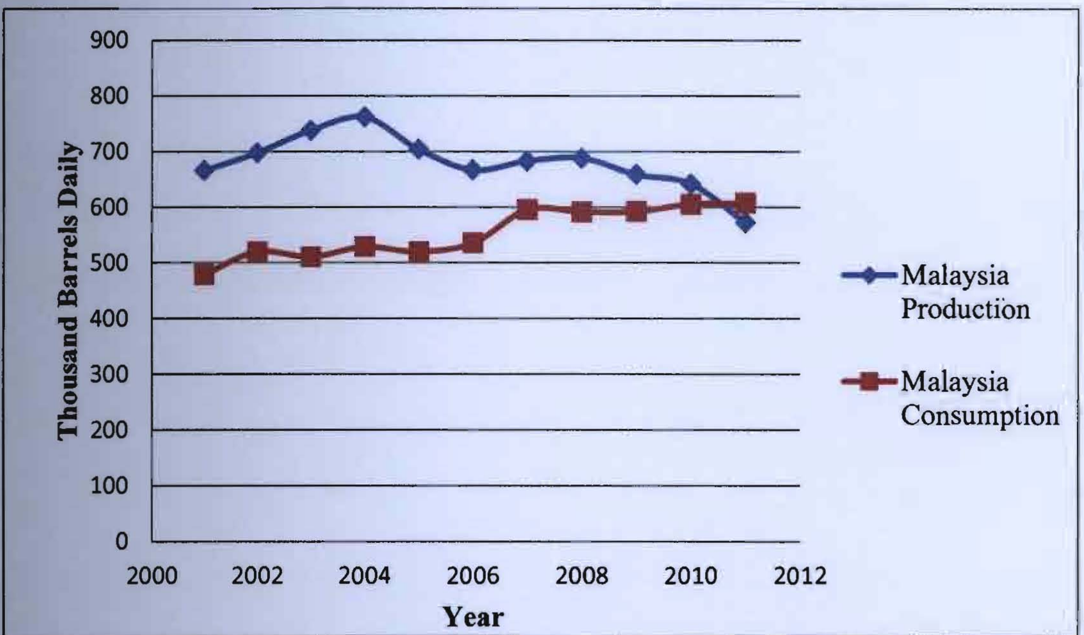

Figure 1.1: Oil production and consumption trend in Malaysia (BP, 2012)

1.2 Problem Statement

The globe is threatened with the twin catastrophes of fossil fuel depletion and environmental degradation. The excessively extraction and consumption of fossil fuels have caused a severe reduction in petroleum reserves. Furthermore, the petroleum based fuels including gasoline, jet fuel, kerosene, and diesel are attained from limited reserves. The world is no longer granted with new sources of economical fossil fuels and professionals have warned about the exhaustion of the